

*Draper (J. W. M.)*

AN

INTRODUCTORY LECTURE

ON

OXYGEN GAS,

DELIVERED IN THE

UNIVERSITY OF NEW YORK,

SESSION MDCCCXLVIII—IX.

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BY

JOHN WILLIAM DRAPER, M. D.

PROFESSOR OF CHEMISTRY.

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NEW YORK, November 16, 1848.

PROFESSOR DRAPER,—

*Dear Sir*—At a meeting of the Students of the University Medical College, held on the 15th instant, DON LEON Y. DE ALVEAR, of Buenos Ayres, being in the Chair, and NEWTON F. VOWLES, of Virginia, acting as Secretary, it was unanimously

*Resolved*, That a Committee be appointed to solicit from your accustomed kindness, a copy of your very instructive and interesting Introductory Lecture for publication. The undersigned having the honor to constitute the above Committee, take great pleasure in expressing the warmest desires of the Class, and most respectfully add their solicitations to those of the Class, and trust that you will not refuse so unanimous a request.

We have the honor to be, Sir,

Your obedient Servants,

LEON DE ALVEAR, *Buenos Ayres.*

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LEON Y. DE ALVEAR, *Chairman, &c.*

NEWTON F. VOWLES, *Secretary.*

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UNIVERSITY, NEW YORK, November 21st, 1848.

TO MESSRS. LEON DE ALVEAR and NEWTON F. VOWLES.

*Gentlemen*,—I have to acknowledge the receipt of your letter, asking for publication, in the name of the Medical Class, my Introductory Lecture.

It gives me great pleasure to comply with this request, and to offer you my best wishes for your prosperity.

Yours truly,

JOHN W. DRAPER.

## LECTURE.

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GENTLEMEN,—

ANIMAL instincts, when properly considered, are often found to be connected with physical laws. Even in the case of man, his gratifications and dislikes frequently originate in the imperceptible action of external circumstances, and those feelings, and the impulses to which they give rise, are, in the scheme of Nature, strangely bound up with other things to which, at first sight, they seem to have no kind of alliance.

Thus, with what pleasure the whole animal world rejoices at the coming of spring. There is a heartfelt delight, not limited to the higher races, but common to all. With the returning temperature birds, and beasts, and insects, prepare for the duties of a new year, and every thing seems full of animation and life. Even the illiterate man cannot look unmoved on the green tint stealing over the fields. Perhaps his sentiments may in some measure be connected with a perception that there is a promise for the gratification of his baser animal appetites, and that this prosperous beginning will end in the production of corn and wine for his use. But behind these, which are the more obvious, there are other causes for rejoicing; causes which can only be fully appreciated by the intelligent, and which have only been made plain by the advances of the highest branches of human knowledge.

How often is our admiration aroused by the work of mechanical artists! The steam-ship, which day after day has continued its unceasing and successful struggles with the waves, or the chronometer, which once wound up keeps on for months together its regulated motion. Yet how far are all these contrivances outdone in the mechanism of each living man. Of his double nervous system one part, the intellectual, observes its mysterious periodicities, its time of activity and time of repose, its time of wakefulness and time of sleep; the other, never sleeps till death, but keeps up its incessant action, the beating of the heart, the introduction of air by breathing, involving millions of movements which never fatigue us, and of which we are indeed, for the most part, unconscious. And now who would suppose that these, the highest and noblest results of a far greater mechanician than man, are ultimately connected with the return of the spring; and that, in fact, the continuance of the life of man is indissolubly linked with the putting forth of the buds of a tree.

Yet so it is; and surely we cannot spend an hour more profitably than in tracing that connection. Such studies are appropriate to our

profession, appropriate to all intelligent men. And when another spring revisits us, we shall not find this hour has been entirely lost. The reflections it may suggest will, perhaps, increase the pleasure with which we view the return of that great natural phenomenon.

In thus explaining to you the connection which subsists between the animal and vegetable kingdoms, I shall have, in the first place, to introduce an account of the greatest scientific discovery of the last century—the discovery of Oxygen Gas—an event rivalling in importance the establishment of the doctrine of Universal Gravitation by Sir Isaac Newton, in the preceding age.

Until the middle of the last century an opinion universally prevailed, that the atmospheric air is a perfectly homogeneous and undecomposable body—that there is but one kind of air, that which we breathe, and though in mines, wells, and other deep and solitary places, substances somewhat analogous occurred, they are in reality nothing more than vitiated forms of atmospheric air, having gathered poisonous qualities from mineral exhalations. From the remotest times these opinions had prevailed. Many of the Greek philosophers looked upon the Olympian Jupiter as only an emblem of the atmosphere, and little suspected that the day would come when that great god of antiquity would be anatomized, dissected, and his various parts and qualities displayed. How often do things which have struck one generation with awe become common-place affairs with another!

It so happened that though from time to time after the thirteenth century different gaseous substances were accidentally encountered, they all possessed the quality of extinguishing the light of a candle, and were therefore incompetent to support combustion, and when breathed were destructive of animal life. The doctrine that these were only vitiated forms of the atmosphere seemed very plausible, and things went on in this way until the middle of the last century, when the capital discovery was made by Dr. Priestley that the air is not a simple substance, and that so far from being the only existence of the kind, there is a great family of analogous bodies, each of the members of which possesses peculiar properties. He completely broke down the ancient doctrine of the unity of the atmosphere.

You can scarcely form an estimate of the immense consequences that followed this event. It was found not alone to affect chemistry, properly speaking, it threw a flood of light on every allied science. The chemistry of that day was overthrown, and it became the foundation of chemistry as we understand it. Without any exaggeration, I characterize it as the capital discovery of the last age, rivalling in its importance, and in its results, the great discovery of the preceding century, Universal Gravitation, by Newton. Extended by the chemists of England, France, and Germany, it has utterly exploded metaphysical physiology, which, taking its origin in the dark ages, has been the great barrier to the progress of rational medicine. Whoever will take the pains to study with attention the works devoted to the exposition of that ancient system, must be struck with the impenetrable obscurity in which it is enveloped. You turn over page after page, and the more you read the more you become confused. It is a constant putting



of words for things, of phrases for facts. Even in the hands of the most powerful writers, metaphysical physiology is essentially unintelligible; but not so with that other physiology which has arisen in our times, all its statements are clear, precise, distinct; it relies on the exact sciences, such as Chemistry and Natural Philosophy, because it is itself exact. The progress of all the departments of human knowledge is often alike. Two thousand years ago the pagans peopled Olympus with many gods; and so in the infancy of medicine the corporeal frame has been peopled with many intangible forms—a soul, a mind, a vital power, an instinct, a nervous agent, an aura, and animal spirits without end. But a better knowledge of these things is fast teaching us the eternal truth, that as there is but one God in the heavens, so there is but one spirit in man; a presiding agent that supervises and directs all. That all the acts of life are brought about by the inhalation of atmospheric air; and that every living animal owes its so-called vital properties to the action of air within its system. That there thus arise oxydations and other alterations in the economy, so that not a movement takes place, nor a thought occurs, without contemporaneous structural changes; changes which I shall demonstrate to you in this course of lectures. The introduction of air by breathing is, I say, the fundamental fact in physiology; nay, more, it is the fundamental event in the action of the brain. I rest my opinions not on scientific facts, though they are numerous and irresistible, but I go at once to an authority far beyond all chemists and metaphysicians. In vain the physiologist asks me to deny the combustive influence of air in the body, and affects a fictitious fear of the tendencies of such a doctrine. Shall I not believe the positive declaration of him who is the artificer of these beautiful contrivances?—shall I, too, dare to accuse my Maker of materialism when he tells me, that “he breathed into his nostrils the breath of life, and man became a living soul?”

The circumstances that first direct the mind of a philosopher to discoveries which are destined to exert an influence over the whole human race cannot fail to be full of interest. So it is in the present case. It happened that Priestley, who resided near a brewery in the town of Leeds, in England, accidentally observed that the beer during its fermentation in the vats gave forth a remarkable aerial substance. The flame of a lighted stick immersed in it was at once extinguished, and the smoke floating on the top of the stratum showed that it was very heavy, a result which was perfectly confirmed by the observation that, invisible and intangible as it was, it could be poured from vessel to vessel like water, and in the vats in which it originally occurred it would overflow their edges and descend to the floor, along which it would run like a stream, its course being readily tracked by the expedient of putting a lighted stick into it, and observing the extinction of the flame. Moreover, he found that it would dissolve in water, for if dishes of that liquid were placed where it had access, an agreeably acidulous and sparkling fluid, soda water, was formed. And that the agent which brought all these results about possessed a physiological potency, was proved by the fatal fact, too often known in such manufactories, that if by accident it was breathed, death at once took place.

The substance which Priestley thus first encountered was that known to us as carbonic acid gas; it had already been studied under other circumstances by Black and older chemists. I mention it here because it led Priestley to that long-continued investigation of factitious airs, which was crowned by the great discovery of oxygen gas.

We have seen with what acuteness Priestley detected differences between the gas just mentioned and common air. It is a striking fact, verified over and over again in the history of science, that the most imposing results may be presented to the acutest mind, and their significance and value remain undetected. Priestley, in 1771, having exposed some saltpetre to the fire, disengaged oxygen, experimented with it, and even showed its energetic power of supporting the flame of a candle, and yet the value of these truths entirely escaped him. Three years after he submitted one of the compounds of quicksilver to the force of the sun's rays, converged by a burning glass, oxygen again escaped, and this time he secured his discovery.

He was not long in recognizing its importance. One after another, as the properties were developed, the value of their consequences was apparent. First, a lighted candle, far from being extinguished, burnt with increased brilliancy, and substances commonly reputed combustible, such as iron and other metals, were consumed as though they were wood. The doctrine of vitiated airs disappeared at once. Here was a substance possessed of all the chemical energies of the atmosphere, only in an incomparably more intense degree. If there were vitiation at all, the air itself was a vitiated form of this gas. Then, too, he found that it could sustain completely the breathing of animals, and that, in reality, it was absolutely essential to the discharge of that function, a fact which led him to apply to it the epithet "vital air;" and lastly, that the atmosphere itself, far from being as the ancients had supposed, a simple homogeneous mass, contained this substance as its active principle, mingled with four times as much of another different body.

Here, before explaining the consequences of this great discovery, and showing you the position in which it stands, I may be permitted to spend a moment in relating the melancholy but interesting history of its author. It is a lesson which ought not to be lost. Born the son of a tradesman, who died while he was young, and left him very poor, his early manhood was spent in the useful but tedious duties of a village schoolmaster. His attention being turned to theology, he subsequently became the pastor of a Presbyterian church. We must not impute it to mental weakness, but rather to a pursuit of the truth, that in succession he passed through many phases of religious belief, and four different sects, the Presbyterian, Arminian, Arian, and Unitarian, received him as a votary. This is not the occasion nor the place to explain the causes which led him in this course. It is only for us to judge of so great a man with charity. But imbued as he was with a deep religious sentiment, and feeling that even the most exalted objects of this life are not to be compared with the importance of another world, he regarded his philosophical pursuits as a very secondary affair, and gave much of his time and talent to controver-

sial theology. He seems to have come to the conclusion that it was incumbent on him to make a religious war. As his biographer says, "Atheists, Deists, Jews, Arians, Quakers, Methodists, Calvinists, Catholics, Episcopalians, had alike to combat him." In more than a hundred volumes which he printed, each of these found an adversary of such force and vigor, (and it was impossible with such a man that it could be otherwise,) that their ablest theological writers were overmatched. By the established Church of England he came to be regarded with such feelings, that instances occurred in which those who had successfully answered him were rewarded with the highest dignities; a circumstance which gave origin to his remark, that he appointed the Bishops of England.

But this was not all. The first French Revolution broke out, and his ardent mind, imbibing with enthusiasm the seductive doctrines of the times, he added to his religious disputes those of a political partisan. As the different sects had in succession stood in fear of him, so now the government took the alarm; they knew his philosophical reputation and ability. The story is a sad and short one. A mob assembled round his dwelling, which they committed to the flames; the houses of those who were known to be his friends, shared the same fate; he narrowly escaped with his life; and for three days one of the chief cities of the nation was the scene of riot. All his philosophical instruments, most of them constructed by himself, his manuscripts, his library, the fruits of a frugal life, were destroyed; and eventually driven from his native country, in his old age he found an asylum in the United States, where Mr. Jefferson, then chief magistrate, received him with kindness and distinction, and here he died.

In relating this melancholy but instructive story, we cannot but remark how Priestley forgot that the experience of all nations and of thousands of years has proved the utter impossibility of any one man convincing the whole human race, and converting them all to his views. He shut his eyes to that anarchy of opinion infesting the world, brought on in no small degree by such polemics as those in which he delighted. In an exact science, like chemistry, he could describe some new discovery, and every man in Europe at once admitted its truth. He never realized how different it is in politics and theology. The library of volumes he wrote on these topics has already dropped into that gulf of oblivion which has received all the works of the authors of the early and middle ages, and no man cares to learn what he wrote or what he thought of the matter. But not so with his philosophical labors; they stand out clear and distinct, monuments of the advance of the human mind in knowledge and power during the eighteenth century. His discovery of oxygen gas will last as long as the world endures.

From the life of this remarkable man we may draw a lesson, peculiarly applicable both to those who, like you, are commencing the medical profession, and also to those who, through years and experience, have attained an elevated standard in public estimation; a lesson which the highest authority, with a brief emphasis, has given us—"Study to be quiet and mind your own business." We here see



a great man effecting his own shipwreck on the shoals of politics and controversial theology. To what an eminence might Priestley have attained, if he had limited himself to those objects for which Providence had so well fitted him, and abandoned the vain pursuits in which he delighted to men of less intellect and force! How is it possible, in our times, for a man to be at once a great philosopher, physician, theologian, politician! He must make his selection of one, and stand by it. Not that I would wish an intelligent member of our profession, whose opinions must always control or guide those of a large circle around him, to shut himself up from public affairs of great interest. If he perceives in those to whom the authority of government is committed, a disposition to jeopardize national interests, and pursue an obvious career of profligacy, let him resist them with whatever influence he has, and give his support to those who are the upholders of the peace, prosperity, and happiness of the nation. I would have him set his face against all social disorganizers, and give no countenance to religious disputants. But otherwise, to stand aloof from all the petty questions of the day, remembering that he has adopted a profession which involves the deepest responsibilities, and demands all his energies and all his time.

In thus freely criticising, for your benefit, a character historic in science, I trust I have not infringed in an unkind spirit the generous maxim—"Say nothing but good of the dead." I join in the dying exclamation of Cræsus, the king of Lydia—"Judge not of the life of a man until you have witnessed his death." And what can there be more touching, or even more beautiful, than the last scene of Priestley's life! it dissipates the remembrance of all his disputations and all his errors, and shows us that beneath these there was a deeply pervading and redeeming faith. When his little children were brought to his bedside to bid him good night, he uttered his last words—"I go to sleep like you, but we shall awake together, and I hope to eternal happiness."

To return from his life to his discoveries. Priestley soon found that oxygen—I give it the name under which it has subsequently passed—was absolutely essential, in all cases then known, to the support of flame and fire, and that animal life depended on it; that a man, by breathing in a limited space, would soon exhaust it of so much of this gas, that suffocation would come on; that the atmosphere, in reality, is a reservoir of it, from which every thing possessing the attributes of an animal abstracts it. It has been shown by succeeding chemists, that to such an extent does this abstraction go, that a single man will each year consume about 800 pounds weight. Considering, therefore, the enormous amount of animal life, the same respiratory process being common to the minutest insect as the largest quadruped, there must be a constant tendency to alter the constitution of the air, for in proportion as we take from it oxygen at each inspiration, we restore at each expiration an almost equivalent bulk of carbonic acid—a double change, the removal of a vital element, and the addition of a poisonous gas.

But Priestley also showed, that in artificial atmospheres, such as he



made, animal life could not possibly go on if there was any great reduction of oxygen, or any great increase of carbonic acid. More recent experiments prove, that the most striking physical and moral effects arise when men and animals are made to respire atmospheres of a different constitution—effects such as we witness in the case of chloroform and sulphuric ether—a remarkable discovery, not, as is commonly supposed, of only a year or two back, but made by Berzelius, who, twenty-four years ago, gave the most extraordinary, and in a scientific point of view the most important, instance of the kind yet produced—the instantaneous and deep sleep brought on by the respiration of hydrogen; a fact which, in the recent discussions about the priority of that discovery, has been strangely forgotten. From the effect thus arising when the constitution of the medium we breathe is in any degree disturbed, it necessarily follows that ever since animal life appeared on this earth, the composition of the air must have been nearly unchanged. But here arises a great and obvious difficulty. If the life of men and animals can only be conducted in such a medium as our atmosphere, and if such extensive changes as I have described are constantly impressed on the air by those beings, how does it come to pass that, after the lapse of a few years, it does not gather a poisonous quality? There must be some agency at work, continually tending to prevent that result. The consideration of what that agency is, introduces us to the second branch of Priestley's discovery.

He had put some mice in a glass containing atmospheric air, closely stopped, and found, as usual, that they died of suffocation as soon as the air became sufficiently impure by their breathing; an absolutely poisonous constitution being gradually assumed. But if a few vegetable leaves, or a small plant, were placed in the glass, and exposed to the sun, in a very short time the poisonous qualities disappeared, and the power of supporting animal life was regained. Here, then, was an unexpected result—a discovery that gave a solution to all the difficulty, and which has been verified in its minutest details by more modern experiments. It has exposed the great and interesting fact, that plants and animals stand in a relation of antagonism to one another; that whatever changes the one tends to impress on the air, the other undoes; and that while animals discharge their duty in consequence of their being living and moving things, plants perform theirs under the influence of the light of the sun; for these changes do not go on in the dark.

Let us look at these facts by the aid of modern chemistry, premising that oxygen is an invisible substance, existing in the air, and that carbonic acid arises from its union with carbon. When charcoal or carbon burns, it is merely uniting with atmospheric oxygen, and the resulting carbonic acid escapes away under an invisible form. So, too, when a man breathes, he draws in oxygen from the air; it is distributed to all parts of his system, and combining therein with carbon, turns into carbonic acid, which is expelled when he throws out his breath. Every animal, therefore, to use the language of chemistry, is an oxydizing machine, the physical end of its existence being to rob the air of oxygen, and put back, in its stead, carbonic acid gas.

With plants it is just the reverse. As long as the sun is shining upon them, they take carbonic acid from the air, and decomposing it by their leaves, they set free its oxygen which escapes away, its carbon they appropriate to their use. With it they form their various parts, their stems, roots, flowers, seeds; but they do this only so long as the sun shines, and when night or winter comes the process stops.

The animal therefore takes from the air oxygen, and turns it into carbonic acid; the plant takes that carbonic acid, and turns it back into oxygen, which has thus discharged the great office of carrying carbon from the bodies of animals, and transferring it to the systems of plants. In what an interesting relation do the two kingdoms, the animal and vegetable, thus stand to one another, not alone as respects the air in maintaining its constitution uniform by a mutual antagonization, but also as respects their own structures. The elements of which plants now are formed, have all been derived from the pre-existing parts of animals; and the elements of which animals now consist, from the pre-existing parts of plants. To the classical scholar, what a beautiful commentary on the fictitious stories of antiquity are these modern discoveries. He calls to mind the metamorphoses that Ovid describes; the bore, perhaps, of his school-boy life, but the elegant amusement of his later years. He remembers how Daphne was turned into a laurel, and Adonis into a flower; the musical stanzas are no longer an empty sound, they are descriptive histories. The thing he has read of is actually so. These transformations, instead of being imaginary exceptions, are the common lot of life in this world. There grows not now a leaf that is not formed from the parts of animals that are dead; there lives not a solitary animal being which has not derived its constituent elements from plants.

Here, then, we are led to a most remarkable conclusion. If the air for thousands of years has remained unchanged, and if these antagonizing processes are all the time going on, equalizing its constitution, it necessarily follows that the amount of vegetable is accurately adjusted to the amount of animal life; the one cannot get the better of the other, for if it did the excess would be instantly restrained by its antagonist, and, in this point of view, these two grand forms of life constitute together a splendid automatic or self-adjusting machine. Men talk about the dullness of science; it is only so to those who are unable to follow its developments to their consequences. Where will you find in the whole range of poetry a conception more sublime than this? The two divisions of the world of organization reacting on each other through the medium of the atmosphere—the living against the lifeless, the moving against the motionless; and not only thus influencing each other through that medium, but maintaining its properties for ever unimpaired, and ready for action. It is the glory of astronomy to have proved that the planetary orbs, which circle round the sun, of which our earth is one, under the influences of a pair of forces thus reacting, can retain their movements undisturbed through a coming eternity. And if astronomy has made the splendid discovery that the inorganic world has attained a condition of eternal equilibrium, chemistry has rivalled it by showing that the same grand truth applies to

the world of organization. To watch the eternal coming out of the transitory will always strike a reflecting mind with emotions of the highest admiration. The sunbeam—the finger of God—that reaches across the unknown abysses of the universe in a moment, bringing life out of death, and clothing the objects around us with their many colored dyes, has extracted this condition of everlasting permanence, from a pre-existing transient order of things.

From considering this adjustment of the animal and vegetable kingdoms to each other, we might be led to the idea that each individual in these natural divisions has its counterpart in the other; an idea bringing us into a new relation with inanimate objects. There is implanted deeply in the hearts of all men an instinctive love of natural scenery—forests, flowers, the green grass—and surely such a sentiment cannot suffer from the thoughts now occurring to us. We establish with such objects a relationship, I had almost said a friendship; they become, as it were, a part of ourselves, things essential to our own existence; and that deep attachment we feel to the place of our birth, or our home, finds its apology not alone in natural instinct, or in acquired habits, but also in the highest philosophical considerations. In imagination we might mark off groups in the two kingdoms which are the fanciful representations or counterparts of each other. Perhaps we men, who have to resist the storms of life, may have our representatives in the rugged trees of the forest; the ladies will certainly find their antagonists among roses and flowers.

From what has been said, you will have gathered how important is the part which oxygen plays in the scheme of nature. To it is committed the duty to destroy all animal races, and transfer the parts of which their bodies are composed to plants. It begins to discharge this function the moment we begin to breathe, pervading each instant every part of our bodies, and bringing on interstitial death, and the continuous removal of particle after particle which it carries away. For there is an incessant change in the substance of all living structures; that which we are to-day differs from yesterday and to-morrow, and this untiring agent is all the time at work, assaulting and undermining, nor stopping its action with our dissolution, but going with us into the tomb, until it has restored every particle back to the air. Death is not, as the popular superstition says, a phantom skeleton, nor as the Asiatics think, a turban'd horseman, who pays his sudden and unwelcome visits. He is this invisible principle in the air which surrounds us, and which is in the very breath we respire.

If thus the duration of individuals and races is determined by the two great systems of forces which have been combined into a self-acting contrivance, it surely is one of the most interesting inquiries in which we can engage, to find in what way so extraordinary a combination has been established. From those remote periods to which we are able to trace the history of the earth, has the same kind of agency prevailed, or have other laws and other self-acting contrivances been resorted to in other times? You see I here assume the doctrine of the geological antiquity of the earth without any kind of hesitation. During two centuries its spherical form was bitterly denied by many very



good and well-meaning men. But the truth at last prevailed. And during the last fifty years its age has in a similar way, and on similar principles, been contested. But this, like the former, is now a settled question; neither the one nor the other is any longer open to debate. He who thinks the earth is only a few thousand years old, simply knows nothing about the matter. He who denies its antiquity will also probably deny its figure.

I proceed then rapidly with the inquiry in which we are engaged, and would premise that there is no fact better established in all the range of physical science than that of Priestley's, heretofore mentioned, that plants grow at the expense of the atmosphere. I farther call to mind the indubitable fact that all the coal, whether bituminous or anthracite, is of vegetable origin; that all the great deposits of these carbonaceous materials, occurring in Europe, Asia, Africa, America, and in the islands of the sea, for hundreds of miles in extent, and of unknown thickness, are vegetable matters, once formed under the influence of the sun-light, and existing as luxuriant forest growths—forests that in succession were entombed in the bowels of the earth. There was then most assuredly a time when all this carbon existed as carbonic acid gas in the air, giving rise to an atmosphere in which, as we know, animal life could not exist. But the sun had charge of the matter, and as centuries rolled by he was extracting that poisonous gas from the atmosphere, effecting its decomposition, as he did for Priestley, bringing forth from it vital air, oxygen gas, and getting things ready for the appearance and continuance of animal life.

I therefore regard, in a philosophical point of view, the period of the deposit of the coal as the great event in the earth's history. Those who are familiar with the details of these things will recognize it as the epoch which parts off a blank solitude on one side, broken by the rude beginnings of low animal life, from that latter period on the other, which is adorned by all the beautiful contrivances of animated nature, and crowned by the presence of man. The laws of nature have ever from the beginning been such as they are now, and we are fully able to trace the clear relationship between the condition of living things on the surface of the earth, and the constitution of the atmosphere; and what chemistry says ought to have taken place in successive centuries, geology tells us actually occurred. Understanding the changing condition of things as respects the air, we could predict the corresponding changes in animated nature, and the evidence that we are right is engraved on the rocks and stamped on the ocean.

So, therefore, we see that that relation which now exists between animals and plants, and the atmosphere, is an affair that has sprung out of a prior order of things. That there was a time when the constitution of the air was utterly unfit for the support of animal life; that a purification took place through the action of the rays of the sun; and the deposit of coal marks out the great epoch when life of a high order, among air-breathing animals, became a possibility. And is it not beautiful to remark how gradually, from a totally different order of things, have sprung those great laws which determine not only the fixity of the constitution of the air, but also the duration of the species



and individuals; that automatic, self-acting machine in which animal and vegetable life are the opposing forces.

In thus sketching out the course of events as we now know them to have taken place in those ancient times, and in explaining how one system of laws has spontaneously been developed out of another, we cannot avoid making a comparison between the feeble contrivances of men, and the means resorted to for the conservation of the world. We are accustomed to look back with admiration to the wisdom of those great men who laid the foundations of this republic, and established a constitution for it; but what would our admiration have been, if it had been possible for them to have enacted one single law of such simplicity and comprehensiveness, that every other law, by any possibility required in all the contingencies of a thousand years, should have spontaneously sprung out of it? if it had been possible for them, by one legislative act, to have completed and brought to a conclusion all legislation? The good and evil which we constantly see arising in our political assemblies, what are they but commentaries on the want of wisdom and want of power of man? But what is not possible to man is possible to God; and I think it will always elicit from a reflecting mind a tribute of veneration, to know that this great and intricate machine of the universe, with all the millions of beings, living and inanimate, that compose it, with all their affections, attributes, and relations, are sustained and governed according to the original and unvarying intention of their changeless Author; that from the beginning of things, as respects its physical condition, there never has arisen occasion for retouching a work perfect in itself from the first. I am not among those who regard this system of acting through ancient and self-imposed law as in any wise derogatory to the Great First Cause. I appeal to the common decision of mankind, whose admiration of any human contrivance or machine is greater in proportion as the machine is self-acting, performing its effects with rigorous precision, according to the conditions under which it was constructed; but less, if the engineer has from time to time to interfere in order to ensure its successful action. I recall that well-known maxim of the law, "*Qui facit per alium facit per se*"—whoso acts through another, acts himself. It makes no difference in my estimation, in this respect, whether the Architect of the universe himself directly interposed, and compelled such a constitution of the earth's atmosphere as was conducive to the ends he had in view, or whether, under the laws he had imposed on it, the obedient sun proceeded to discharge that task, and put forth his rays with unwonted effulgence, bringing on a great increase in the amount of vegetable life, a great depuration of the atmosphere, the burial of enormous quantities of carbon in the ground, and the gradual assumption by the air of that condition suited to the support of a high organization, and of the life of man. I appeal to the experience of us all—each of the celestial phenomena we witness, the revolutions of the stars, the return of comets, the occurrence of eclipses, each of the changes that happen on earth, the flux of the tides, day and night, summer and winter, the budding of trees and unfolding of flowers, the rise and fall of empires—do they not all take place, not through present

and incessant interventions, but in obedience to ancient law? I recall what we all witness as respects the social condition of man, that according as he advances in intellect, he lives under self-imposed rules, and that his reverence for law is the measure of his civilization; that it is the pride of that civilization to put in the place of an autocrat, dispensing instant rewards and punishments with his own hands, the ideal majesty of the law, which deals out inflexible justice to the good and evil, and makes no distinction of persons; and reasoning in this manner, from insignificant beings and small things to those which are great, I conclude that a Pure Intelligence will rarely act by intervention, but always through law.

Through that astronomical agency to which I have referred—the action of light exerted during the period of the deposit of the coal—a purification of the atmosphere was effected to such an extent, as gradually to enable warm-blooded animals to exist, the temperature to which they attain being directly dependent on the amount of oxygen they take from the air. All animals, from the first period of their coming into existence to the moment of death, are continually by their respiratory effort obtaining this gas, so essential to their very existence, and as continually expelling the effete and dead matters of their systems, under the forms of other airs—carbonic acid, ammonia, and the vapor of water. And thus the atmosphere is the source from which our bodies come, and to which they return, continually during life, and, with the exception of their earthy ingredients, totally after death, and the gases that are found in it are at once the agents and objects of the change. Had Priestley realized these things, could he have induced Chemistry by her witchcraft to compel the gas he had discovered to tell its own story, and how it determined his destiny, his imaginative but theological mind would perhaps have recalled the similarity of his own adventurous inquiry, and that of the old Jewish king who visited the sorceress at Endor. Awakened by the power of her spell, there arose from the enchanted circle over which she waved her wand, the form of an old man whose face was shrouded in his mantle. And he said, “Why hast thou disquieted me, to bring me up? To-morrow shalt thou and thy sons be with me.”

Some seek for pleasure in the mere gratification of animal appetites, let us rather find it in the exercise of the intellect; and when Spring approaches, let us rejoice in the change, not so much because there is a promise of food, though we should never forget that all these vegetable products of which so many are destined to delight our tastes, were mortal poisons while they were yet in the air, but chiefly because they are indications that all that is necessary for us as thinking beings is accomplishing. I have told you that the continuance of the life of man is indissolubly linked with the putting forth of the buds of trees. Let the one fail, and the other will speedily stop. Nay, more; as all our intellectual acts can only go on as a consequence of respiration, and the respiration, too, of such an atmosphere as that of our earth, we perceive that our highest endowments are thus connected with things at first sight apparently having no alliance with them. And though it is thus, that arch-chemist, the sun, who transmutes a poisonous gas in

the air into fruits, and seeds, and flowers; who prepares the vital medium that we breathe, and enables us therefore to think and move, shall we not look with veneration, through his more obvious agency, to a silent influence that is beyond? For these products of his action are so many witnesses to us of a provident foresight for our physical and moral wants. There is an authority who has taught us not to disregard such natural emblems. Who is it that has set his rainbow in the cloud, as the pledge of a plighted word? We are surrounded on all sides with similar indications, and are constantly invited to see in each material event a token of intellectual benefit; and if, as we have seen, from a poisonous atmosphere there has thus gradually been developed, under the agency of that great celestial body, a medium suited to the well-being and conducive to the happiness of man, may we not hope that what has taken place as respects his physical, is a type of what will occur as respects his social condition. Who that looks on the events which this year has brought forth—the overturning of thrones and time-cemented institutions, the bloodshed and atrocities of civil wars—who does not recognize that we are entering on an era? The material atmosphere once had a poisonous constitution, the social atmosphere has its poisons too. There is a cry, almost of despair, from the Baltic to the Mediterranean, from the Black to the Atlantic seas. It is no imaginary nightmare that is oppressing the men, but so greatly has the human mind been developed by the advance of knowledge, that it has outgrown the existing order of things. The pressure of that invisible social atmosphere has become too intolerable to be borne; it must be cleared of its impurities and poisons, there must be freedom for thought and freedom of action. The natural change which we have been considering was only brought about after many a convulsion; the moral change must have its catastrophes. But are we not taught, from this evening's reflections, to trust that there is in this too the influence of One far greater than the sun, but of whom the sun is the most noble and appropriate type, who, unaffected by the tempests of the times and the sufferings of men, is steadily shaping the course of events, to bring things at last into a condition suitable for the intellectual as well as the physical well-being of our race?

